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ABSTRACT

An education satellite offers the technology to enhance the quality, control the cost, and expand the available opportunities of secondary school education. The satellite is the vehicle through which change can be effected in the secondary school system, particularly to bring quality education to the segments of the population now in sparsely populated or economically disadvantaged areas and to bring into the school system a greatly improved awareness of all phases of today's culture and science. The education satellite will have a strong impact on teacher training, the core curriculum of conventional subjects, the education of special groups of students (gifted, handicapped, and adults), and the responsiveness of pre-college education to the changing needs of a technological society. A selected bibliography is included. (Author)

SECONDARY SCHOOL APPLICATIONS OF AN EDUCATION SATELLITE

by

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Abstract

An education satellite offers the technology to enhance the quality, control the cost, and expand the available opportunities of secondary-school education. The satellite is the vehicle through which change can be effected in the secondary-school system, particularly to bring quality education to the significant segments of the population now in sparsely populated or economically disadvantaged areas and to bring into the school system a greatly improved awareness of all phases of today's culture and science.

The education satellite will have a strong impact on teacher training, the core curriculum of conventional subjects, the education of special groups of students (gifted, handicapped, and adults), and the responsiveness of pre-college education to the changing needs of a technological society.

SECONDARY SCHOOL APPLICATIONS OF AN EDUCATION SATELLITE

An education satellite in geosynchronous orbit with sufficient radiated power to allow inexpensive, general receiver stations offers the opportunity for delivery of educational materials to a geographically broad region (1/3 of the earth's surface), including sparsely populated and educationally disadvantaged regions. The following sections focus on the opportunities provided by such a satellite system for secondary-school education -- grades 7-12 for students in the regular track, but also encompassing equivalent education for special audiences such as adults or the physically handicapped.

I. Objectives

The use of satellites in U.S. secondary-school education requires change in an educational system which is now severely constrained by fiscal pressures and by an imminent, sharp drop in enrollment because of plummeting national birth rate after 1958. Within these constraints, change represented by satellite utilization must depend on the confluence of several factors:

(1) Reduction in cost. In the few regions where enrollment is rising, cost reduction can be sought through increase in the student/faculty (or student/staff) ratio. If enrollment is falling, cost reduction is more difficult and is usually tied partially to staff attrition.

(2) Improvement in quality. Educational improvement is a goal more directly realizable, particularly through the possibility of using the satellite to aggregate markets for special programs or courses by virtue of its broad geographical coverage. Thus, the satellite can both enrich the regular programs and offer vastly more choice to the student and teacher.

(3) Enhancement of educational opportunity. A satellite provides the opportunity for significant expansion of educational opportunity by its coverage of areas either sparsely populated or economically disadvantaged.

The education satellite activities must meet all three criteria in an overall sense, although specific programs or courses may well have to be carried by other activities. As one example, special education for the physically handicapped is 3-5 times as expensive as regular education and may alone justify other activities which primarily improve quality. The increasing cost to society of functional illiteracy provides an opportunity for the satellite system to justify a large portion of its program in an overall cost/benefit analysis.

The following paragraphs are restricted to secondary-school education, perhaps the most difficult area in which to justify economically the use of a satellite, but at the same time an area in which a satellite system can have a truly significant impact. The economic difficulty arises because secondary education, already significantly more costly than primary, is under the greatest public pressure for cost control at just the time enrollments are starting to fall. The opportunity arises because of the national need for enrichment in this educational level, the desirability of a wide range of choices for the students, and the new demands imposed by society in functional literacy, career education, health education, and vocational education -- all arising from the awareness of the critical nature of these transition years into adulthood.

The following section discusses these opportunities in more detail under the broad categories of

(1) Teacher education
(2) Core curriculum
(3) Special students
(4) New educational needs

Any study of the potentiality of a satellite system has to be primarily an analysis of the current needs of secondary education, since the satellite activities, offering the opportunity for radical change in the educational system, will be used only when the new technology fills a perceived need within existing economic constraints. Thus, satellite utilization depends on the availability of high-quality, educational materials at a time selected by the user and in a format consistent with the existing educational program. In other words, success of the satellite activities depends on[1]

(a) Tangibility -- specific text and materials

(b) Flexibility -- possibility of use in many different ways and settings

(c) Conventionality -- close analogy with familiar courses or materials

(d) Match to environment -- absence of disruptiveness in the adoption

Unless all four criteria are satisfied, educational change will require intensive retraining of teachers and persuasion of local decision-makers. Thus, as each category (1) - (4) above is considered, the assumption is made that criteria (a) - (d) are met through proper planning and federal support for the development of appropriate materials for students, teachers, and the community.

II. Educational Opportunities

An education satellite provides the opportunity for secondary schools or local learning centers to receive televised programs for either real-time viewing or, with minimal recording equipment, taping for viewing at a time selected by the teacher or student. Regional planning should include facilities for local requests for particular programs and, in cases specifically justified, capabilities for interactive use of the educational materials. Thus, the satellite represents a flexible and adaptive system for widespread distribution of audio-visual materials

either in real-time or upon demand with moderate time delays. Furthermore, the ATS-6 system demonstrated the attractiveness of parallel audio channels to allow audio signals tailored to the needs of particular sub-sets of the total audience. From this base, the following opportunities are particularly attractive for secondary education.

(1) Teacher training

Teacher education becomes especially important in a period (such as the next decade) when very few new teachers are entering the schools because of enrollment declines and when, at the same time, the new demands are placed on the schools. For example, the movement toward measurement of functional literacy in reading (as well as in mathematics) places entirely new requirements on the teaching of English, as well as other courses. Once the functional literacy tests are widely administered to students at grade 9, curricular materials will be available for instruction of failing students -- materials unfamiliar to the teachers. The earliest functional-literacy tests have already demonstrated vividly the need for entirely new teaching materials.

As a second example, the growing national emphasis on teaching students to write leads to strong interest in the research on classroom techniques and procedures (an interest emphasized by the fact that 50% of the freshmen at some of the better colleges are in remedial courses). The Bay Area Writing Project, under Professor James Gray of the University of California at Berkeley, is one low-cost program with startling promise of success -- a program which can only be effectively explained to teachers with video portrayal of the classroom situation. The program is built on such fundamental concepts as the importance of students writing essays specifically for a small number of known peers, and the focal contribution made by reading one's essay aloud to these peers with mutual criticism and commentary. The successful implementation of the program can be taught to teachers through actual television pictures of the complex organization of the

class and consequent operation.

As other programs for more effective teaching of basic literacy skills succeed on local levels, the education satellite offers a unique technology for dissemination, regardless of the particular literacy involved. As teachers are increasingly evaluated quantitatively, whether by formal competency-based procedures or in broad terms of student performance, and educational accountability is a public concept accepted nationally, the need for continuing education for teachers will become more and more urgent during a time when cost constraints will severely limit the in-service and summer training programs which have been the principal vehicle for in-service training in the past.

Teacher training is also important in the area of new educational needs discussed in part (4) below: new curricular demands require re-training of teachers in an era of very limited faculty expansion.

(2) Core curriculum

The satellite offers unusual opportunities to enrich the core curriculum in the secondary schools: the courses in humanities, arts, social and behavioral sciences, and sciences including mathematics. In each area, public concern is increasing for the quality of student achievement, which seems to be diminishing if National Assessment or CEEB scores are an indication.

In the humanities area, the education satellite provides the possibility of availability of an extensive repertoire of taped plays, poetry readings, and critical discussions of classic or modern literature. The German course, now on TV tape at the State University of New York, is an example of the possibility of reversing the decline of interest in and availability of modern language instruction in the high school.

Within the area of the creative arts, the former radio programs of Walter Damrosch and the more recent work of Leonard Bernstein demonstrate dramatically the power of telecommunications technology to enrich the educational experience

for students, particularly those in the small rural schools.* The commercial-television programming on such topics as the life of Michelangelo or the British series on 19th-century French art demonstrate the richness of available materials which, for secondary-school education, must be accompanied by appropriate class-room, teacher, and student materials. The exploding interest of the U.S. public in ballet, opera, and classical music, as evidenced by the response to the program of the National Endowment for the Humanities, emphasizes the weakness of this phase of formal, pre-college education.

In the social sciences (including history in the secondary schools), television already has provided series such as the Adams Chronicles and Upstairs-Downstairs, as well as a wide variety of programs focussed on the bicentennial. Annually a large number of prize-winning commercials is available as a mirror of social development and the growth and decay over the years of public attitudes.

The social sciences in the secondary schools also should cover current critical issues: e.g., the on-going debate over the expansion of nuclear generation of electric energy or the recent concern with the initiation of regular Concorde service between Europe and the U.S. In such cases, the education satellite offers the opportunity for live coverage and, if two-way audio communication is available, for response to student questions and interactive discussion. The live coverage can include real-time coverage of either actual events or carefully staged, realistic simulations (e.g., with measurement and re-creation of the noise levels accompanying Concorde take-off, or the presentation of Secretary Coleman's decision).

Finally, a major weakness of existing social science courses is the lack of adequate coverage of the ways in which federal or state policies develop and how new programs are initiated within government. Such essential elements as the role of authorization and appropriation bills in the Congress are not generally appreciated

*Rural America encompasses more than 25% of the population and still includes 10,000 one-room schools. The principal weaknesses of the rural, secondary schools are in art, music, language, science, and industrial arts.[2]

by the public or even briefly discussed in conventional courses.

In the science area, the education satellite offers the potentiality for bringing the frontiers of modern science into the classroom at low cost (with, for example, films of amniocentesis and fiber optic measurements within the human body substituting for the field trips of the past). In the last few years, radical changes have been developing in science education at the secondary-school level. For example, a few of these national projects are:

(a) Project Physics (or Harvard Project Physics) under the direction of F. James Rutherford (completed 1970). This was somewhat unusual in that it had support from the U.S. Office of Education as well as the National Science Foundation and private foundations. The high school course emphasizes physics with a humanistic bias and includes historical and biographical material, qualitative as well as quantitative material, and a relaxed writing style. The target audience was announced as the 85+% of the students who do not take high school physics, but the course is actually appealing primarily to academic, college-bound students.

(b) The Man-Made World (Engineering Concepts Curriculum Project) under the direction of E. Joseph Piel (SUNY at Stony Brook) -- completed in 1972. Also aimed at college-bound students who do not take Physics (and often Chemistry), this course focusses on the basic elements of information or system science: modelling, decision-making, dynamic systems, feedback and stability, logic circuits and computers. The course emphasizes a quantitative approach to the technological

environment and the actual systems surrounding and impinging on the students.

(c) ISIS -- Individualized Science Instructional System under Ernest Burkman (Florida State University). One of the largest of the on-going NSF projects, ISIS is at about the halfway point in the development of 60 mini-courses, each independent and requiring 3-4 weeks. The idea is that the school can use perhaps 10 per year throughout the high school. Each minicourse is designed to allow self-paced learning, and each has various terminal points to appeal to students with different career motivations. The central theme is the teaching of basic science concepts in terms of relevant, real-life problems (e.g., "packaging" individuals to protect them in auto crashes).

(d) BICP -- Biomedical Interdisciplinary Curriculum Project under Leonard Hughes, California Committee or Regional Medical Programs. This project is particularly interesting for several reasons:

(1) It has been apparent for some time that human and physiological systems are a superb vehicle for teaching physics and chemistry, as well as biology. (At M.I.T. a freshman physics text is being developed in terms of biomedical engineering examples entirely). The motivation seems especially powerful for students in high school and possibly junior high school (where the distaste for science currently seems to arise).

(2) The goal is a two-year curriculum for the junior and senior years covering a double period in bioscience and one period in both mathematics and social science. Like the Richmond plan, the program attempts to capitalize on this coordination of three courses so that each reinforces the others.

(3) Throughout the program, students learn health-career information, and the basic goal of the program is preparation for college education in the total range of health careers.

While the Project is career oriented, the most exciting characteristic is the introduction of an entirely new set of exciting and relevant examples as a basis for teaching fundamental concepts in the physical, life and social sciences.

(e) HSGP -- High School Geography Project (Association of American Geographers). A tenth-grade course focussing on the themes of settlement and urban geography, the course is marked by a wide range of student activities and multi-media materials (completed in 1970).

(f) CPE -- Comparing Political Experiences at the Social Studies Development Center of Indiana University and under the American Political Science Association. The materials can be used either for a total course or as distinct elements of a normal social science program. The course, with an investment of $1.3M so far, is interesting because it has to face the problem of treating topics which are politically sensitive.

(g) EHN -- Exploring Human Nature at Education Development Center. This cross-disciplinary course draws from biology, psychology, anthropology, and sociology to address the themes of origins of human behavior, childhood and the community, coming of age, managing transitions, and individuals in society. Again the emphasis is on a wide variety of classroom activities, such as an experiment on natural selection and the design of a community.

(h) TPE -- Technology, People and Environment at SUNY at Stony Brook. This project is generating 150 one-day class activities grouped in minicourses. The content is derived to a considerable extent from The Man-Made World (b above), but is specifically designed for non-academic, under-achieving students.

These are only a sampling of the NSF-supported programs in the physical and social sciences.[3] Important efforts also exist in environmental studies, mathematics, anthropology, and other fields. From these very brief descriptions, however, certain common characteristics can be noted. Through the projects runs the theme that science can be taught effectively within a framework which provides motivation for the student -- even the student who has no interest in a career in science. This motivation is achieved by relating the science to phenomena and problems clearly important to the individual or to society -- an area in which the education satellite offers focal contributions.

When an attempt is made to make science a relevant and obviously useful subject, two problems arise. First, consideration of a specific problem commonly

involves more than one field of science; the classical compartmentation into earth sciences, biology, chemistry, physics, and mathematics is just not compatible with real-world problems. Second, science alone (without the social and behavioral sciences and humanities) leads to simplistic solutions, often obviously ridiculous.

These characteristics are illustrated by the topic of auto accidents. The unwillingness of Americans to use active restraints and the political refusal to stop the combination of drinking and driving both can be appreciated only in terms of the behavioral and social sciences which, with economics, impose severe constraints on any national program to reduce accidents. Indeed, the simplest cost/benefit analysis of auto safety features inevitably leads into consideration of the complex problems of the balance of payments and international economics.

Unfortunately, once science is broadened in this way, acceptance of the courses in the schools is severely limited by hesitancy on the part of many teachers to become involved with open-ended courses in which the problems considered may have no solutions, solutions beyond the knowledge of the teacher, or solutions which are politically or socially sensitive. Science teachers, particularly, are accustomed to teaching problem-solving in which there is one correct procedure and a single correct answer. They are not used to free-wheeling class sessions, in which their task is that of discussion leader rather than lecturer or chief problem-solver. It is exactly here that the education satellite has the potential for the greatest impact, regardless of the specific field involved.

(3) Special students

The education satellite is especially attractive for programs for special groups of students at the secondary-school level. Within this broad realm, four principal groups are particularly important:

(a) Gifted students. Even in the large and relatively wealthy suburban schools, the largest group of educationally disadvantaged students are those especially gifted -- those who frequently complete high school work is appreciably less than the normal time and who find the regular courses a limited academic challenge. For these students, even in the isolated rural areas, the education satellite offers the opportunity to deliver college-level or advanced courses or minicourses. There are already available on TV tape four basic college courses which have won widespread acclaim: the Miami Dade environmental studies offering, and the three courses (psychology, anthropology, and critical issues) from Coast Community College in California.[5] All four are appropriate for gifted high school students in the last year and can be administered for college credit at low cost to the student or school district. Other courses are available on basic calculus, physical science, etc.

(b) Remediation work. Here principal effots have been directed to self-paced instruction in such areas as algebra. Consequently, the role of the satellite would require the development of appropriate motivational and explanatory material.

(c) Handicapped students. The satellite, with appropriate ground terminals for local redistribution by cable or broadcast or tape, permits reaching students with physical disabilities which inhibit school attendance.[4] Captioned television programming

and audio-only channels are directly applicable to the handicapped with hearing and sight deprivation, respectively. Educational programs for the mentally disturbed and those with learning disabilities are already in use in major urban areas.

(d) Adult education. Finally the education satellite allows continuing education for the adult audience at the secondary-school level. In 1972, 566,000 U.S. adults were studying basic literacy and fundamental skills, and over nine million were taking non-credit educational programs. In the rural areas, there exists a need for education on such pragmatic subjects as employment opportunities, individual health care, social security benefits, use of food stamps, and so forth.

For each of these special groups, the satellite is the technology which allows that aggregation of the market for educational materials which justifies federal and national expenditures essential for quality production. The satellite permits realization of the goal of reasonable educational opportunity for all the population -- a goal which previously could only be considered for densely populated, urban areas.

<u>(4) New educational needs</u>

In recent years, major emphasis in secondary education has been placed on career, vocational, health, and consumer education. The ATS-6 satellite experimented with career education on a small scale, but again here a major development of high-quality materials (including for the teacher and the student) is essential. Career education must be accompanied by self-evaluation and guidance materials -- on a large scale probably most efficiently utilizing the computer as in the ETS SIGI system for those students with access to a transmitting ground terminal.

Among these four categories, consumer education (in the broadest sense of that term) is the most recent of the emphasis on secondary education. Here such federal responsibilities as those for energy conservation or fire prevention and control will lead to governmental support for the development of educational materials, since public understanding is essential for amelioration of the problem. For example, the per capita fire losses in dollars or human lives in the U.S. is more than double that in any other nation -- certainly in part because of the absence of relevant educational activities.

The primary new development in secondary education during the past decade has been the impact of the electronic digital computer.[6] There are six major ways in which the computer is used in the learning process:

(a) Computer programming. Students are taught algorithmic problem formulation and the conversion of algorithms into a computer program using some programming language (typically, BASIC, FORTRAN, or APL).

(b) Computer science. Computer programming is taught with consideration of computer organization, design of computing devices, as well as computer applications.

(c) Computer literacy. Consideration is given to how computers operate, how they are used in society, and the benefits and the problems created by these applications. The primary focus here is on the creation of informed citizens.

(d) Computer-assisted instruction (or CAI). Essentially, in this application, the computer is used to implement programmed instruction. The computer evaluates the student's performance as he progresses through the course material and,

on the basis of this evaluation, directs him one way or another. Along the way, the computer keeps a record of the student's activity, so that it can provide the teacher with a progress report on each student.

(e) Computer-augmented learning. Here, the computer is used in one of several ways to assist students in their learning activities:

a. Problem solving

b. Development of algorithms

c. Simulation and games

d. Reorganization and retrieval of information

(f) Computer-managed instruction. The computer is used as a manager of instructional materials (including CAI, computer-augmented learning-materials, films, slides, books, resource people, etc.). The computer keeps track of where each student is in the curriculum, administers tests, and, on the basis of the test results, directs the student to the next step.

During the past decade, computers have been applied to the learning process at all educational levels, and in all of the ways described above. This activity, which started in the early 1960's with a few experimental projects run primarily by university people and funded by federal agencies and private foundations, has spread rapidly until now much of the effort and funds are locally generated.

The paragraphs below look briefly at a number of national projects which have achieved some level of success in applying computers to the educational process.

(a) Dartmouth Computer Project. Probably the first effort to explore seriously the use of computers in education was at Dartmouth College under the direction of John Kemeny and Thomas Kurtz. Kemeny and Kurtz developed one of the first time-sharing systems and the computer language called BASIC (the most widely used programming language in educational institutions). When their system was developed, Kemeny and Kurtz explored its utilization at their own school and, in addition, provided access to the computer for many high schools and small colleges in New England.

There was some staff assistance provided to the outside schools to help them get started in computing, but, primarily, the Dartmouth staff acted as a clearinghouse to collect and disseminate experiences, applications, and programs among the participating schools.

(b) Huntington Two Project. This project was funded by the National Science Foundation to explore the utilization of simulations in high school classrooms. Huntington Two has developed thirty simulations in biology, physics, and social studies which have been used in a wide variety of pre-college environments, as well as in two-year and four-year colleges.

(c) TICCIT is another project supported by the National Science Foundation. Its primary objective is to demonstrate that CAI can be used to provide learning experiences which are educationally sound and simultaneously cost effective. TICCIT has two components: the hardware and software which comprise the delivery system; and the courseware which comprises the educational content of the system.

The TICCIT system has not yet been evaluated at the time of this writing, because the delivery system was completed only at the beginning of this year, and the courseware has not yet been utilized extensively by students.

(d) PLATO, also funded by the National Science Foundation, is a project whose primary purpose was to develop a delivery system which is easy for teachers to use to create computer-supported educational material for their courses, and which makes effective use of modern technology in the delivery of this educational material for their courses. The PLATO staff has developed the most sophisticated and most impressive delivery system in existence. It is useful in support of all of the six computer-related approaches described above.

There has been a large body of courseware over a wide range of disciplines developed for PLATO, although there has not yet been a careful evaluation of the effectiveness of this material.

(e) SOLO, and its successor SOLOWORKS, is a project run by Thomas Dwyer at the University of Pittsburgh, again with support from the National Science Foundation. Dwyer defines two kinds of student computer -- "solo-mode" and "dual-mode". The terms "solo" and "dual" come from an analogy with flight training where, during the early phases of training, the student and teacher fly in dual mode; after the student has gained some proficiency, he is permitted to solo.

The Huntington Two Project and TICCIT, described above, are examples of dual-mode computing, where the student uses programs generated by others. In SOLO, the student programs the computer himself. The SOLO staff has generated a number of modules in matrix operations and in computer-augmented calculus to guide the student in writing programs in these areas.

In Soloworks, the student is motivated to learn mathematics by participating in projects which require mathematics for their completion. The student conducts these projects in one of five unusual laboratories. These laboratories are in computers, dynamics, logical design, synthesis, and modelling/simulation. These laboratories include a flight simulator, "Rube Goldberg" machines, and a computer-controlled organ.

Soloworks is in its early stages and so its level of success is not yet clear; however, the students and staff involved in the project are very enthusiastic about their experiences. One serious problem with Soloworks is the considerable expense involved in equipping the laboratories.

It is difficult to tell with any accuracy how extensively computers are used in pre-college education, but it appears that between 25% and 40% of all high schools in the United States now use computers in their academic programs.

When computer support of instruction is considered there are two developments which have emerged within the past two years which hold great promise to impact education much more dramatically and more pervasively than has been true up to now. These developments are the microcomputer and the

pocket calculator. Microcomputers currently are available which are the computational equivalent of $6,000 minicomputers and which cost only $1,500. Further developments in large-scale, integrated-circuit manufacturing over the next five years promise to bring this cost into the $500 range, with the likelihood that it will drop to under $200 within a decade. With these cost reductions, computing will be available to every student and every teacher, with educational consequences which can, at best, be perceived dimly.

The pocket-calculator has become almost an inexpensive as the transistor radio (simple four-function calculators are available for under $20, and there is one with mathematical functions -- log, sine, etc. -- for $30). There are only a few efforts under way to explore the utilization of pocket calculators in the classroom. It already is clear, however, that the calculator will raise serious questions about the kinds of mathematics taught. Are there concepts in the calculus which can be presented to a wide range of students, or can they be brought into earlier years?

As microcomputers drop in cost, the primary role of education satellite will be in the delivery of educational programs to allow all of the public to participate in the computer revolution, both in education and in all phases of everyday life.

III. Conclusions - Recommendations

The education satellite holds the promise of aggregating educational markets to justify economically and socially the development of a wide range of new educational materials designed both to improve the teaching of functional skills for today's society and to enhance the excitement and motivation of the students. The telecommunications capability, at the same time, permits expansion of educational opportunity to large segments of the population currently divorced from the mainstream of educational development.

At the secondary-school level, the primary role of the satellite is as a telecommunication distribution technology with capabilities (in at least part of the system) for two-way, interactive communication in real time. The materials distributed for the secondary-school use will primarily be one-way communication with system organization to satisfy user requests with moderate time delays.

Realization of the potential impact of this modern communication technology will depend upon not only the technological facilities, but, equally importantly, the national organization for the coordinated development of high-quality, timely, and appropriate materials. The relatively small number of suitable, existing television courses, among the many now available, illustrate the importance of aggregating creative, technical, and financial resources in parallel with the market aggregation. From the federal standpoint, this resource aggregation means close coordination of the educational efforts of relevant, mission-oriented agencies and departments.

Each of the educational areas discussed in Section II should be the focus of a formal, organized effort with national coordination of resource development to parallel technology development and organization of the delivery system on a regional basis.

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